The Future of the Grid

Evolving to Meet America's Needs

Southeast Region Workshop Summary

April 8, 2014

Durham, North Carolina

Prepared for the U.S. Department of Energy by Energetics Incorporated under contract No. GS-10F-0103J, Subtask J3806.0002.

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Introduction

The U.S. electricity system is undergoing a major transformation that will continue for the next 25–30 years. The rapid evolution of electricity supply and end use will have major implications for reliability, transmission and distribution, customer engagement, security, and integration.

Regardless of the ultimate generation mix or the policies in place, the electric grid will play a critical role in future electricity infrastructure. In fact, it is an essential, enabling platform that supports America's economic activity, similar to the cellular network, which enabled the world of smartphones and mobile applications.

Thoughtful debate and planning are needed today in order to address tomorrow's challenges and seize on tomorrow's opportunities. With this in mind, the GridWise Alliance (GWA) and the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability (OE) are hosting a series of workshops across the country (four regional workshops followed by a national summit) to develop an industry-driven vision of the nation's future electricity grid. During the regional workshops, thought leaders from all stakeholder groups (utilities, regulators, state government officials, renewable energy providers, suppliers, and industry innovators) are coming together to define the needed capabilities, the changing role of grid operators, the new technologies and financial models required to drive investment, and the policy and regulatory barriers to realizing the vision.

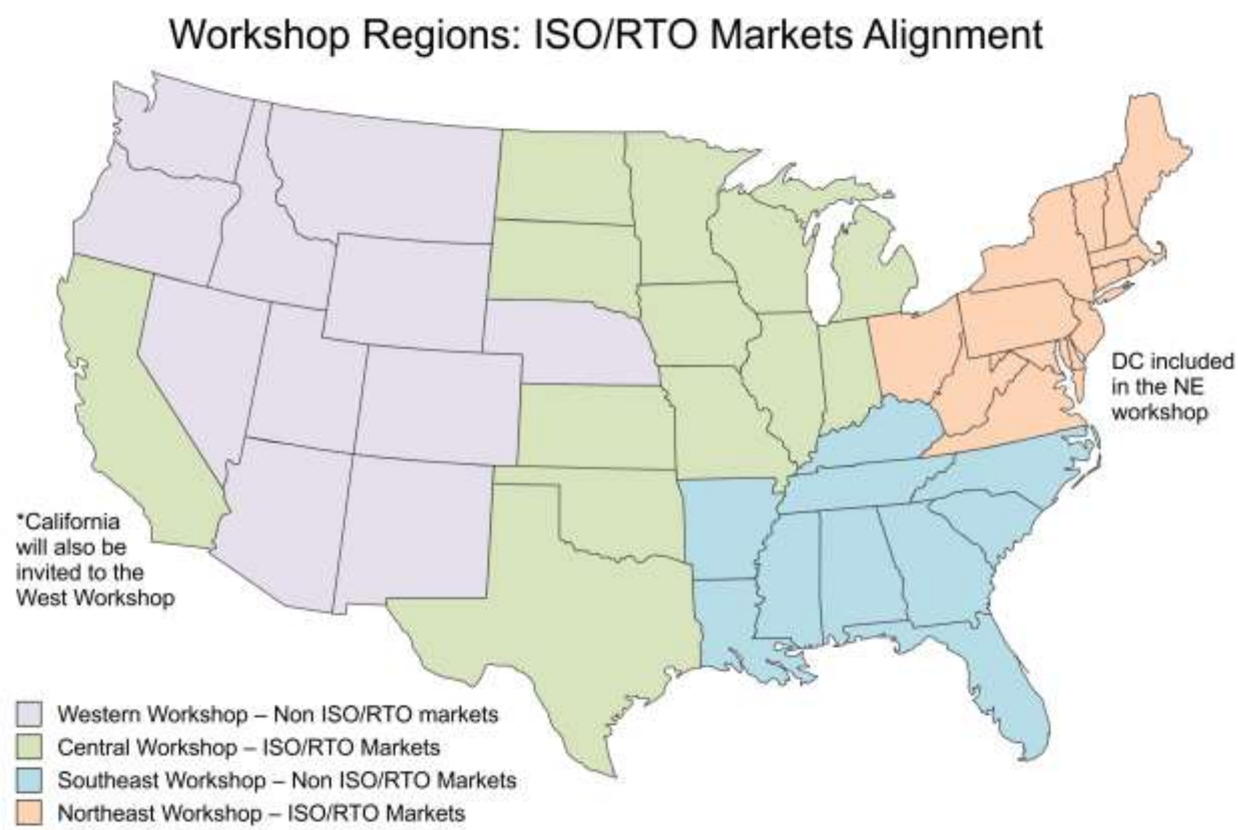

Figure 1. Workshop region designations

The region designations for the regional workshops are identified in Figure 1 and align along Independent System Operator (ISO)/Regional Transmission Organization (RTO) markets. California, due to its unique characteristics, was included in both the Western and Central Region workshops.[1]

Following the regional workshops, a national summit will take place in Washington, DC, to review, synthesize, and validate the findings and themes that emerge from the regional discussions. The results from this effort will inform larger DOE efforts to help guide research and development agendas and serve to educate all stakeholders—including state and federal policy makers and regulators—on the issues that must be addressed to ensure that the future grid is affordable, reliable, and resilient to support economic prosperity and energy security.

[1] California is geographically aligned with the Western Region and shares many renewable energy and environmental drivers common to other Western Region states. California is also aligned with the Central Region in terms of its use of an ISO to regulate its wholesale market and the nature of the utility-customer relationship.

Workshop Approach

The structure of each of the four regional workshops is the same. The day begins with a visioning exercise in which participants are asked to forget the current legacy system and think about the type of system they would design today if starting anew. Participants are then split into breakout groups, each of which is given a different scenario to discuss considering a future state of the grid in 2030. The breakout groups then participate in facilitated discussions to answer questions about grid capabilities, grid operations, business models and investments, and regulatory and policy barriers and opportunities in the context of their assigned scenario, while keeping in mind the vision for the future grid. The workshops feature open and frank discussions by employing Chatham House Rules, which permit participants to speak freely without the fear of attribution. The complete workshop agenda for the Southeast Region workshop can be found in Appendix B.

Although the scenarios are anchored in key factors affecting the grid, they do not represent an exhaustive examination of what is possible in 2030. Instead, they highlight the most likely scenarios and key areas that are plausible and facing industry today. The scenarios serve to guide the discussion of "2030 grid operations" from important and somewhat different perspectives. Participants are asked not to debate whether the scenario will occur, but to consider what new technologies, capabilities, or policies would be needed or what limitations might exist to transform today's system into the future vision.

The same scenarios are discussed at each workshop:

- Balancing Supply and Demand as Grid Complexity Grows
- Involving Customers and Their Loads in Grid Operations and Planning for Empowered Customers
- Higher Local Reliability through Multi-Customer Microgrids
- Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Regional differences emerged from the different workshops as these scenarios were discussed throughout the country. These differences are included in each region's stakeholder-driven vision and will be captured as part of the broader national-level vision.

The Southeast Region workshop—the third in this series—took place in Durham, North Carolina, on April 8, 2014. Forty-eight participants attended the workshop; Figure 2 shows the breakdown by stakeholder group. The complete list of attendees is provided in Appendix C.

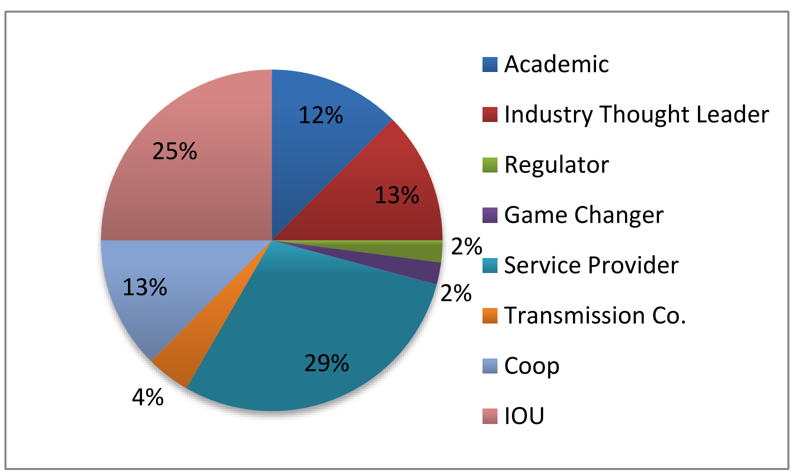

Figure 2. Breakdown of Southeast Region workshop participants

Participants were given an extensive set of pre-read materials before the workshop describing the scenarios and highlighting factors to consider. These materials set the stage for the workshop and provided context for the discussions. Appendix A contains a summary of the key factors participants were asked to consider.

Key Findings

Participants at the Southeast Region workshop appreciated the diversity of opinions and the liveliness of the discussions. Participants noted the benefit of bringing together a diverse set of stakeholders in an engaging environment to discuss such an important topic. Throughout the discussions, several key themes emerged about the characteristics and needs of the electricity grid in 2030:

Operations

- **Real-time, automated communications to end-user devices and equipment will be needed.** There will be ubiquitous sensing of grid components and end-use devices with interoperable communication. Devices will have two-way communication with the grid and will be largely automated. Automation of end-use devices will be based on customer preferences. Operations will feature more decentralized decision making.
- **Huge amounts of data will create a need for robust communications.** The large amounts of data used for controlling and monitoring the grid will require fast communications. Enhanced forecasting for demand optimization and sophisticated dispatch will be needed, as well as improved analytics of near-real-time data. Better tools will be needed to analyze the huge amounts of data and support automated operations.
- **Energy storage will mitigate intermittency.** Energy storage will be a critical component because it will provide flexibility for managing and operating the grid. It will allow opportunities for mitigating the variability in solar photovoltaic (PV) and wind energy systems, as well as for some spinning reserve requirements. Energy storage could also be an important microgrid component for this reason and could improve the technical and economic feasibility of these systems.
- **Multi-customer and single customer microgrid operation will be complementary to the grid system. New interconnection technical standards for multi-customer microgrids will be necessary.** Microgrids will complement the grid instead of competing with it, providing services to utilities and vice versa. Aggregating distributed generation into microgrids might offer benefits for managing significant concentrations of distributed generation and customer-owned renewables. Utilities will be able to call on these microgrids to island on peak demand days or for other operational efficiencies, including reducing the impacts of outages. This will be a win-win when the customer and utility work together.
- **There will be more coordination between transmission and distribution operating centers.** There will be transactions going from distribution to transmission, so the operating centers will need to be more tightly integrated. There will be greater cooperation on interfaces and operating centers, both horizontally and vertically. More visibility into the distribution grid will be needed, which will bring transmission and distribution operations closer together.

Business Models and Pricing

- **The role of the utility will shift from commodity provider to customized consumer services provider (i.e., all-premise management).** A modernized grid will enable additional services and products that are not possible today. Utilities will be able to provide and possibly manage a slate of options and services directly for consumers such as distributed generation, electric vehicles (EVs), reliable power, energy efficiency, distributed solar, and targeted demand response. Services will provide consumers with options related to what they care about (e.g., the environment, cost, and cutting-edge technology). When offering new services, utilities will need to keep in mind that some customers will just want their lights kept on.
- **New rate structures should be created for all grid services (e.g., backup power).** Currently, barriers exist around rate structures that do not allow utilities to offer the services that customers want. These barriers need to be evaluated to determine how they should be

addressed moving forward. The rate structures must adapt to allow for new technologies and the associated capabilities they deliver. To make the required infrastructure and maintenance investments, utilities will need a reasonable and established method of recovering the costs incurred, particularly for providing grid backup service to "net zero" customers. Capital and operations and maintenance (O&M) costs associated with the maintenance of grid infrastructure could be recovered via a fee.

- **Costs should be disaggregated.** The cost of electricity services needs to be broken out to show the actual cost of each component so that consumers can understand what they are paying for and better understand the services they are receiving.
- **The grid will be an energy marketplace platform that enables transactions.** The grid operator will enable an energy exchange. This could involve EVs, new rate plans, green energy, distributed generation, rooftop solar, etc. Consumers will have energy where they want it, when they want it.

Policy

- **Utilities should be able to compete openly with other entities providing services and be able to offer services behind the meter.** Currently, utilities only provide services upstream of the meter, and regulated utilities have to be preapproved to do anything behind the meter, which keeps them from implementing new ideas. A partnership is needed between utilities and customers for developing behind-the-meter options.
- **Customers bear the costs associated with the services they receive.** Capital investments were made to build today's grid infrastructure. Customers who have their own generation but want to connect to the grid for reliability or other reasons must contribute to the overall infrastructure they are using and from which they are benefiting. If customers want to use their own distributed generation but still connect to the grid as a backup service, they need to pay for the associated cost of this service.
- **A full suite of interconnection policies and rules will be needed to ensure that microgrids are complementary to the grid system.**

Summary of Messages to Policy Makers

During the breakout sessions, participants identified the most important messages for policy makers to consider when developing future policies:

- **The investments that will be required to enable future grid operations must be understood, and the investment and rate case timing mismatch must be aligned.** Predictability in policy is needed, particularly across states. Certainty is needed regarding incentives and net metering to help reduce or flatten the boom/bust cycle, which is not good for any of the stakeholders.
- **The regulatory mandate for low-cost, reliable energy should be kept, but an additional mandate to reward innovation for the benefit of customers should be added.** Current regulations do not allow for innovation. The regulatory barriers to innovation need to be eliminated while the positive aspects of the current system are maintained. Any proposed changes should be evaluated to determine if they will be beneficial.
- **It will be critical to address the question of the utility's obligation to serve for islanded customers.** Microgrid customers operate in parallel and receive benefits from the overall grid infrastructure. The utility's obligation to serve microgrid customers when difficulties arise needs to be clearly defined. In addition, a cost-sharing component for these customers should be included to account for the grid infrastructure needed to support their interaction with the grid.
- **A bidirectional distribution market for electricity—to and from microgrids—needs to be created.** In a manner similar to how a transmission market clears generation at a particular price, electricity should be put back on the distribution market at its value.
- **Policy can unintentionally distort efficient planning.** For example, incentives to build distributed generation that may not match up with production and consumption needs.
- **Rate reform must start now.** Rate structures need to be reformed, and a method of paying for existing infrastructure needs to be developed. The disaggregation of costs needs to start now; industry should not wait until there are problems, and the issue cannot wait until 2030. Customers should be educated about the true costs and be allowed to pay for what they need. Currently, a component of the price of electricity is socialized, but customers may only want to pay for services they are using. How the socialized component is handled needs to be addressed.
- **A long-term outlook for policy is needed.** There needs to be a roadmap that provides checkpoints that ensure continued progress along the right path. Policy makers should be educated about the benefits of the current system and cautioned to bring about change thoughtfully not based on uninformed speculation.
- **Account for people who cannot transition to new technologies.** A substantial number of customers will be unable to participate in microgrid or solar efforts (including people who live in apartment buildings, not just people who cannot afford these technologies). Grid policy needs to account for both those who can and cannot participate.

Summary of Necessary Actions

During the breakout sessions, participants recommended actions that should be taken as well as issues that must be considered in order to facilitate the evolution of a cost-effective, reliable, and resilient grid of the future:

Overarching

- **Develop a clearinghouse of best practices, data, benchmarks, and case studies on grid investments.** A national resource base or clearinghouse should be established that would enable industry to learn from the experience of others. A collection of case studies could be used to show the benefits of smart grid technology.
- **Educate the regulatory community, consumers, and policy makers.** The landscape of the electricity industry is changing rapidly, and it will be critical to educate stakeholders in order for them to stay abreast of the changes. The regulatory community and policy makers will need to be educated to help them understand the nuances of operations and how policies and regulations will impact the business of running utilities. Customers have varying levels of understanding about electricity delivery. They will need to be educated on how electricity works, what the costs are, and the complexities and simplicities of electricity. Customers and other key stakeholders will need this understanding in order to accept the transition in pricing for electric services. Customers should be educated in *their* language, not in technical language.
- **Coordinate a multi-stakeholder planning and education process.** Industry stakeholders should be brought together in a coordinated planning and education process. Stakeholders should include utilities, grid operators, independent power producers, third parties, consumer advocates, and regulators.
- **Build a comprehensive coalition of stakeholders to drive regulatory reforms.** Open and frank conversations among all stakeholders will allow for various perspectives to be heard and taken into account.

Operations

- **New service offerings should be linked to market analysis.** Utilities should perform market analysis to better understand customer segments and the services that customers want.

Business Models and Pricing

- **Establish rate structures that will make utilities and consumers "whole."** Both utilities and customers need to pay—and be fairly compensated—for the services they receive or provide.
- **Create a more granular understanding of the cost of grid services and accurately allocate the costs and benefits.** The cost for electricity needs to be broken down into its components in order to develop new service pricing structures. These components and pricing structures will need to be effectively communicated to customers so that customers accept them. These cost components will then need to be mapped to the benefits they provide.

Policy

- **Develop transparent, bidirectional, real-time, distribution-level markets for the buying and selling of services.** Utilities, policy makers, and regulators need to determine the additional services that will be offered by utilities beyond electricity (i.e., beyond the kilowatt-hour), as well as the type of services that utilities will purchase from consumers and third parties. Once the types of markets are determined, distribution-level markets will need to be established. Everyone should be allowed to participate in these markets.

- **Ensure flexibility and diversity in business and regulatory models.** Regulation and policy must be aligned with technology and capability.
- **Enable regulations and policies that ensure customer choice.** This will be necessary for both residential customers and businesses. Customers must be kept at the forefront of decisions. Customer choice and options must be balanced against the "physics" of operating the grid to the established standards.
- **Policy and regulation that allow utilities to compete with solar PV suppliers must be addressed.** The competitive market with utilities and third parties needs to be reconciled with the various utility regulatory and business models so that utilities can participate in these competitive new markets. The playing field should be leveled for both nonregulated utility subsidiaries and other companies.

Opening Remarks

Mark Wimberly, General Manager of the Program Management Office, Grid Modernization, at Duke Energy, provided opening remarks on external factors and variables impacting future electricity delivery. He first reviewed past progress, noting that before the American Recovery and Reinvestment Act (ARRA), industry had mainly invested in projects to make incremental changes and upgrades. He stated that the funds provided through ARRA made transformative projects possible and helped to spur the transition to a stronger, smarter, more reliable, and more efficient electricity system.

Mr. Wimberly noted that in order to achieve transformative changes, the energy sector, which is traditionally slow to adopt change, needs to address a number of challenges. First, he noted that energy prices continue to rise and that with these price increases, customers are expecting greater value and reliability. Second, he said that utilities are being held to a higher standard by customers and regulators. Third, he remarked that utilities in the Southeast Region are behind in developing customer technologies, and that they need to listen to customers and create value for them. Fourth, he stated that the industry is moving from a commodity business toward a services/solutions-based business, and that there are challenges associated with the transition.

To address some of the challenges facing industry, he explained that what utilities need from regulators is the ability for quick development of products and services and the fair use of innovation. He stated that the long time frame for rate cases creates uncertainty and makes it difficult for utilities to justify the necessary large investments. He also noted that it is important for utilities to talk with and educate regulators so that unintended consequences that are detrimental to utilities, grid operation, and customers can be avoided, and that the opportunities offered by new technologies can be effectively integrated. In addition, Mr. Wimberly stated that there is a need to address net metering in a thoughtful manner that accurately reflects the cost and benefits to the system.

Mr. Wimberley stated that addressing these challenges will also require new technologies that utilities must incorporate, and that utilities must be engaged to ensure appropriate standards are implemented and benefits to the customer are realized. With microgrids and new technologies, he said that utilities can provide benefits to customers by combining their technology and grid expertise. He stated that utilities will need to embrace this strategy in the future.

Mr. Wimberly concluded by discussing what utilities can do today to increase their chances of achieving grid modernization success. He asked whether utilities are pushing themselves to unlock the possibilities of current technologies. He also said that utilities should reconsider how they frame their future grid investments, and that the budgeting and planning process needs to be connected to strategic visioning efforts. He noted that this approach would allow utilities to make large coordinated investments over a longer time horizon instead of only focusing on incremental improvements.

Vision: Capabilities and Functions of the Future Grid

Becky Harrison, CEO of GridWise Alliance, introduced the large group Visioning Exercise. She asked participants to consider the capabilities and functions of the future grid starting with a "blank sheet of paper." This brief exercise was not intended to produce a consensus; instead, it provided participants with an opportunity to brainstorm in order to expand their thinking and envision the grid without the constraints imposed by the legacy infrastructure and business models. The exercise informed and stimulated conversation in the breakout group discussions that followed.

Elements of the Future Grid
Brainstorming Ideas from Workshop Participants

- Generation will be predictive rather than reactive, and it will not exceed what is needed. There will not be any spinning reserves.
- No carbon emissions by 2030, with ubiquitous, inexpensive storage of renewables to use as needed.
- A totally resilient grid: One that is able to assess and isolate any issues and that has the analytics to solve the issues in real time. It possesses distributed generation and microgrids.
- A smaller distribution system with on-site generation and battery storage (more affordable self-generation for rural communities).
- An economic model that ensures entities bear the fair cost of what they use and receive fair cost for what they provide.
- One conductor size throughout the system.
- Increased resiliency.
- A distribution system that is more networked.
    - No radial system.
- Overall grid resiliency and increased distributed generation may have an inverse relationship—an increased deployment of distributed generation means fewer people will be paying for grid infrastructure, which is detrimental to building out resiliency.
- Technology should support reliability and economics; there should not be technology for technology's sake.
- All wires are underground.
- Common utilities (electric, gas, telecommunications, water) are all interconnected.
- A more flexible regulatory structure at the retail level.
- Responsive to new information; new technologies and externalities to respond to new information.
    - Information and data has to be a fundamental part of managing the future grid.
- Customers must be educated so they understand the services they are getting from the utilities.
    - As utilities transition from a commodity model to a services model, customers need a portal to be able to view their consumption.
    - Utilities will be able to offer ancillary services (as customers become more knowledgeable) and create other service offerings.
    - Customers (especially Millennials) will want immediate feedback and will educate the utilities about what they want—utilities will be responsive.
- Utilities and other entities will provide products that consumers care about.
- Utilities will not be penalized for creating new products and services. The regulatory regime will allow for responsiveness, and there will be lower barriers for introducing new products.
- Perspective can change. Efforts are developing in natural gas and storage by 2020.
- Solution providers will possibly assume some of the costs to serve low-income customers like the utilities do.

- A transactive energy market—a broker will be needed where surpluses and deficits need to be managed, financially and physically.
    - This will cause a blurring of federal and state lines.
- Due to technology and innovation, nonregulated players will enter both big and small generation. Regulated utilities will probably shrink in size.

Other Thoughts Presented by Participants

Competing with Energy Storage – *Participants were given a scenario in which there is a mixture of central and decentralized generation, with the possibility of storage becoming a competitor for utilities. They were then asked about the impacts on the grid if storage becomes a competitor.*

- The utility could offer storage.
- Storage is a good global product; the challenge is for local utilities to market it broadly.
- Storage is not necessarily competition for the transmission system. The grid is a tool for providing power; storage provides the ability to back up that power.
- Perhaps better marketing is needed. Utilities could hire advertising marketers to communicate utilities' products and services.

Role of Public Policy – *Participants were asked about the role of public policy for ubiquitous service if a lot of unregulated competitors enter the market (currently, a portion of rates are subsidized).*

- Innovation will be needed between public policy makers and utilities. An example of the Lifeline program for phones was presented and applied to electricity: basic electricity service could be offered for free, with additional services having a cost.
- Society has grown accustomed to a system where utilities and ratepayers are responsible for offering services to low-income households. Tax revenue may better support that societal aim compared to rate-paying.
    - Social policy is difficult for utilities, so tax revenue may be a good option.
    - If a tax, then the question of whether the money should be spent on the central grid or distributed systems needs to be answered, as well as why the grid is a better choice.
    - Solution providers and other third parties will need to assume some of the responsibility that the utilities bear if they are using the system; this will alleviate the burden to the utilities.
- Policy should provide a single, consistent vision for the industry that provides direction on the wide range of public policy goals.

Other Thoughts

- There are two diametrically opposed views on how to modernize the grid: One view is to "hyper-invest" for reliability, multiple service offerings, etc. Another view is to not build infrastructure as distributed generation grows. Which is the most efficient?
    - Might be similar to the movement to cell phones away from landlines—customers move toward distributed generation, and utilities can focus on industrial/large customers.
    - Free enterprise, capitalism, and social and cyber responsibilities will guide the grid as well.
- With storage being offered and net-zero building codes being enacted, it is hard to make the case for new utility generation for 2030—new neighborhoods will put in their generation.

Scenario 1: Balancing Supply and Demand as Grid Complexity Grows

Description of the Scenario

This scenario is characterized by:

- On the customer side: increased distributed generation and storage at the residential level as well as larger distribution-size renewables; for example, microgrids, community renewable projects, smarter home energy management systems, smart appliances, and EV charging.
- On the transmission side: increasing penetration of non-dispatchable generation sources ("large wind"), more utility-scale renewables, and utility-scale energy storage.
- Increased use of customer devices or generation to balance the system or provide ancillary services.
- Increased dependence on smaller generation versus large base load generation or peaking plants to manage the system.

Together, these characteristics suggest a need for:

- Managing two-way power flows for the distribution grid, not only the transmission grid.
- Enhanced balancing capabilities to balance more complex supply and demand options. Greater dependence on "edge-of-the-grid" devices.
- Greater interaction between the distribution and transmission grids and grid operators to optimize the balancing of supply and demand.
- Enhanced weather forecasting methods.

Path Forward: Articulating the Vision

The following summarizes the Scenario 1 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 1 assumptions. The participants also recognized that there will be a transition period before the end state is reached.

Description of the Group's Future Grid, Based on the Scenario

- **Virtual "power plant."** The virtual power plant model allows multiple resources and loads to be viewed and controlled across the system so that the benefit can be maximized and any issues that might arise can be mitigated. This model requires visualization from the feeder level to the system operator level so that operators can see the output of distribution resources and the capability of storage resources at any time. It would be good to see this in every control system. Utilizing smart inverters on PV systems would allow utilities to manage these systems as a resource when needed, without causing any issues for the owner. In the Southeast, which has mostly vertically integrated utilities, a single entity could look across the system and down to the device level to aggregate the response from these technologies. That aggregation could then be used in the generation dispatch model. Different models are emerging. There are existing virtual power plants today (e.g., data centers), but cost is a barrier. The value of aggregating distributed assets will continue to increase as renewables are added and coal plants are removed from the grid.

- **Real-time, automated communications to end-user devices and equipment.** The grid will have to be largely automated—devices will communicate with the grid, but they will need to be automated based on customer preferences. There will be a wide range of building types and customers (e.g., Millennials versus Baby Boomers) with different needs and requirements; some customers will be very engaged, and others will just want the lowest-cost and most-reliable power without having to think about it. A robust family of solutions will be necessary to meet the needs of the different customer and building types.
- **Energy storage will mitigate intermittency.** Energy storage will be a critical component because it will provide flexibility for managing and operating a grid. It will allow opportunities for mitigating variability in solar PV and wind energy systems, as well as for some spinning reserve requirements.
- **Increased investment in reliability and O&M will ultimately help reduce costs and increase resilience.** Business models that still allow for capital investments to reduce O&M costs will be needed; however, utilities will also need to be rewarded for wisely spending money on O&M to improve reliability without an associated capital investment. An example is the ongoing expense of technology and communication systems that sense and report potential outage conditions. The overlaying of technology will increase some O&M expenses while resulting in lower O&M expenses associated with fixing problems after they have caused an outage.

New Capabilities and Functions

- **Strengthen the grid to support distributed generation.** As distributed generation is added, utilities will have to evaluate the impacts on the current infrastructure of changes to voltage and current flows. These impacts could include the need to increase conductor size (e.g., increase capacity of lines) or even require additional "phases" (e.g., adding another conductor) to be built into a location to balance the power flows on the distribution circuits. With distributed generation on the system, there are impacts to the voltage profile on the distribution circuit. Utilities have had to ask solar providers to pay for circuit upgrades to minimize the voltage impacts associated with distributed solar installations.
- **Strengthen the grid to support enhanced reliability and resiliency.** New "smart grid" switches can move loads to reduce the impacts of outages. To fully leverage the opportunities in such switches, utilities will have to increase the size of some conductors, allowing additional circuit ties between different circuits (feeders).

Differences for the Operations Centers

Transmission:

- **[None identified]**

Distribution:

- **[None identified]**

Business Models and Investments

Financial/Business Model Changes:

- **Services model for distributed generation.** Utilities could provide a variety of new services such as distributed generation, meters, EVs, reliable power, energy efficiency, distributed solar, and very targeted demand response. Utilities could also offer to manage a variety of services for customers. When offering new services, utilities will need to keep in mind that some customers will not want to know the details; they will just want their lights kept on. Barriers currently exist that prevent implementation of this services model—these barriers need to be eliminated. If this happens, external entities would need to be allowed to enter the market.

- **Regulated utilities cannot access tax incentives for solar distributed generation.** Technology is ready; regulation takes longer. Currently, tax incentives that are available to third-party suppliers are not available to regulated utilities. It is hard for businesses to react to boom and bust regulations.
- **Net metering policy modifications—probably state by state—are likely needed, as well as greater education.** Different policies exist. Net metering means different things to different people. There is a need for greater understanding of the nuances of net metering at large scale versus the residential/distributed scale. The net metering conversation only applies to distributed, rooftop-based solar, not utility-scale solar in the field; this distinction should not be forgotten, and the right analysis needs to be applied. The details of the net metering agreement are critical. Some customers participate in a net metering model that pays them the same amount that utilities charge for electricity. A portion of electricity rates is allocated for the maintenance of the wires and infrastructure; therefore, these customers are being paid for the infrastructure and wire maintenance costs rather than contributing to those costs. Other customers have to carry the entire costs for the overall system. As more customers participate in this type of net metering model, utilities lose income and the burden of maintaining the system falls to the other customers. With this structure, net metering customers are using the grid like a storage system—as backup electricity—but are not paying for the storage capacity. The cost of backup power—which requires the overall system to be maintained—must be recovered, and net metering customers should contribute to these costs. Open and honest discussions are needed as part of the net metering discussion. There is value from both the grid side and the solar developer side; they need to engage and work together. As net metering policies are modified, it will be necessary to be mindful of those who made investment decisions based on the current policy, so they are not adversely impacted.
- **The policy around EVs needs to be addressed.** There are numerous questions about EV policy: What is the best policy? What incentives are needed, and how should the policy be reconciled with ensuring sufficient maintenance of highway infrastructure investments?

New Investment/Funding Requirements:

- **Larger lines and capacity of the grid.** To accommodate more distributed resources on the system, additional and/or higher-capacity conductors could be needed. If so, funding for this will be necessary.
- **Greater reliability and O&M.** Utilities are currently incented to invest capital to improve reliability. Investor-owned utilities (IOUs) are generally less incented to invest in O&M because they receive no profit from these investments (i.e., pass-through costs). Depending on the rate case process within a particular jurisdiction, the disincentive to spend O&M dollars can be large or small. Between rate cases, IOUs work to minimize O&M in order to increase the return to their investors. This can drive short-term decisions that have long-term impacts (e.g., reduce vegetation management activities—cut fewer trees). IOUs should be incented to drive for better performance and to drive cost out of the system, which would benefit customers. An example of this would be investing to improve grid efficiency, which would then reduce fuel costs, which are pass-through charges to customers.
- **Smart grid technology and automation.** An autonomous grid with overview from a central entity will be needed. Smart grid technology and automation for seamless control of the

distribution and transmission systems will be needed so that local generation and demand can be more directly managed. With more distributed energy and renewables, real-time information will be needed because balancing will need to happen in real time. Interconnection standards and rules for governing the interconnections will need to evolve very quickly in order to fully leverage these new assets and capabilities and provide the maximum value to customers.

- **Utilities need to be incented to invest time and resources into understanding customers' needs and to collaborate with key stakeholders.** Utilities need to be more proactive and "lean forward," which includes working with customers on the forefront (e.g., approach Walmarts and Targets). Engineering and economic mindsets need to be merged. Engineers need to be brought together to partner with development companies, local governments, and local economic development entities to capture externalities. The collaborative solution can then be brought to the state level. "Leaning forward" and envisioning the grid of the future requires a commercial and economic mindset.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Understand what investments are required for future grid operations.**
    - **Consider how boom and bust policy affects the investment and business operations.** Predictability in policy is needed, particularly across states. Certainty is needed around incentives and net metering to help reduce/flatten the boom and bust cycle, which is not good for any of the players. Transparency will be needed. Sensitivity must also be shown to those who have already made investments.
    - **Investment and rate case timing mismatch need to be resolved.**

Additional Thoughts on Policy Solutions

- Policies should take a longer-term view of what least-cost and prudent investments may mean.
- Policies should consider what is best overall, not just what is best for a single entity.
- Policies should look at the best overall approach that matches costs and benefits.
- Other considerations include policy transparency and structure—identifying who benefits and how that benefit is quantified in cost recovery.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Accurately allocate costs and benefits.** The costs for electricity need to be broken down into components and communicated to customers. These costs then need to be mapped to the benefits they provide. Policy transparency and structure—identifying who benefits and how to quantify that during cost recovery—will be needed.
- **Establish a rate structure to make utilities and consumers "whole."** Both utilities and customers need to pay for and be compensated for the services they receive or provide. Transparency will be essential. Consumers and commissioners will need to be educated. Many customers do not understand why power companies raise rates; utilities will have to educate customers on certain costs and why they are included in the rate. Utilities have to balance

where they want to increase costs with considerations for the impact on their customers. The new rate structure must also recognize that there will be a transition period; the system must be modernized and costs for O&M must be recoverable.

- **Ensure flexibility and diversity in business and regulatory models.** Regulation and policy must be aligned with technology and capability. The timing of investments to deliver the needed capabilities will be critical.
- **Enable regulations and policies that ensure customer choice.** This will be necessary for both residential customers and businesses. Customers must be kept at the forefront of decisions. Investments and standard offerings that enable customer choice will have to be balanced. Customers will also need to be educated on making good decisions regarding their electricity usage and what steps they can take to adjust their usage.
- **Address policy and regulation that allows utilities to compete with solar PV suppliers.** The competitive market with utilities and third parties needs to be reconciled with the various utility regulatory and business models. The playing field should be leveled so there is good competition among independent utility subsidiaries and other companies. Some utilities have to get commission approval to own distributed generation. In contrast, third-party solar PV suppliers do not have to get commission approval, and they can take advantage of tax incentives for which utilities are not eligible. As a result, it can be cheaper for the solar developer to install the product and the utility to buy it back. However, at least one participant noted that this could potentially be an issue with the incentive structure rather than the regulatory structure.

Regulatory and Policy Barriers and Opportunities

The group also identified regulatory and policy barriers and opportunities:

- **As the shift occurs from a commodity provider model to a services model, predictive models that are comprehensive and adaptive will be needed.**
- **Make sure regulation is fully implemented to ensure continued and stable operation.** Mandates to spend money need mandated results; for example, mandated smart meter deployment alone does not do anything but spend money—the smart meters have to be used correctly. It must be ensured that policy produces the desired effect.
- **Interoperability standards are an important goal, but they are challenging and may require middleware solutions. The participants did not reach a consensus regarding how policy can influence this but noted that it should not be mandated.** Interoperability is a higher priority than just technology. Greater interoperability will lead to greater integration. The challenge is that government has tried to facilitate this but left it with standards development organizations, which is a very slow process. With technology changing so rapidly, this is a real hindrance to technology deployment. Industry is moving very fast; utilities are used to deploying assets for 25–30 years, but that is not going to be the case in the future.
- **Need to shift perceptions surrounding utility trust and data privacy.** Some customers do not trust utilities with data even if they knowingly or unknowingly already provide comprehensive information to many other private companies. Perhaps marketing could help with this issue.
- **Desire to align costs and benefits.** This includes matching expenditures and cost recovery.
- **Incentives to utilities to provide increasing reliability over the long term.**

Scenario 2: Involving Customers and Their Loads in Grid Operations and Planning for Empowered Customers

Description of the Scenario

This scenario is characterized by:

- Retail availability of smart devices and customer expectations that devices will "plug and play" with grid operations.
- Greater customer control over, and ability to react to, the price of energy. A greater number of available service options.
- Increased availability and prevalence of smart devices, along with EVs that can respond to signals from the grid operator. Devices are capable of two-way communication with the grid.
- A significant increase in local (edge-of-grid) clean generation (such as rooftop solar), electrified transportation, and storage to meet individual customer (residential, commercial, and industrial) needs and expectations. Ancillary services being met through the control of these devices. An imbalance between reduced/falling overall demand and higher peak demand.
- Technological innovations, new market structures, changing customer expectations, and policies that foster customer empowerment.
- Customers being more informed about their options, in part due to social media.
- Rising electricity prices and falling distributed generation costs, which lead customers to more closely consider their options.
- Increased interest in energy efficiency.
- Customer behavior changes as a result of education, resulting in lower electricity demand.
- Policies that are playing a part in grid modernization, including net metering rules.

Together, these characteristics suggest a need for:

- The ability to incorporate complex economics with complex physical integration.
- An architecture and design that can optimize the loads and their response in a way that maximizes efficiency and minimizes costs.
- Ways to synchronize the operation of potentially millions of devices at the edge of the grid.
- Ways for the grid to adapt when edge-of-grid devices are scaled from hundreds to tens of thousands. Customers are unaware how their own choices impact larger grid operations; when these individual decisions are scaled to hundreds or thousands of devices, the impact to grid operations will be tremendous.
- A "transactive energy" concept, representing the complex interaction between physics and economics at the edge of the grid.
- Recognition that customers now have choices for meeting their specific electric power needs.
- A better understanding of customers' needs, desires, and choices.
- A better understanding of how increasing customer expectations and choices impact the distribution grid and the transmission grid.
- Consideration that by 2030, customers will have a profound impact on how the energy value chain is built and operated.

Path Forward: Articulating the Vision

The following summarizes the Scenario 2 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 2 assumptions. The participants also recognized that there will be a transition period before the end state is reached.

Description of the Group's Future Grid, Based on the Scenario

- **Ubiquitous sensing of grid components and end uses.** The grid will have ubiquitous sensing for all types of devices—with interoperable communications—extending into the consumer realm (apps, etc.), including devices inside the home. Utilities will need to be able to understand the data and how it can be transformed into actionable information for consumers. Customers will need to understand what the data means and how it relates to them.
- **Utilities will provide a slate of options for consumers to choose from.** Utilities will offer numerous options related to what consumers care about (e.g., the environment, cost, and cutting-edge technology). There will be a trade-off between costs and environmental impact, but consumers will not have to choose between environmentally conscious and low-cost options; they will be able to take advantage of environmentally beneficial options without higher costs.
- **The grid will be an energy marketplace that enables transactions.** The grid operator will enable an energy exchange. This could involve EVs, new rate plans, green energy, distributed generation, rooftop solar, and so on. Consumers will have energy where they want it, when they want it.
- **Huge amounts of data will create a need for robust communications.** The large amounts of data used for controlling and monitoring the grid will require fast communications. Enhanced forecasting for demand optimization and sophisticated dispatch will be needed. With large amounts of data, the grid will be better monitored and controlled.
- **Temper the complexity of customer offerings.** Customers can be overwhelmed if they are offered too many options. Utilities should be mindful of this and possibly offer a limited set of products and services. Cost should not be masked; utilities should be transparent about what customers are being charged. Customers should have to *opt in* to services.

New Capabilities and Functions

- **End-use consumption data becomes a way for utilities to provide predictive services to customers.** Utilities will manage automated, intelligent systems that gather a lot of information about customer energy use. Utilities will be able to use this information to help customers use energy more efficiently (e.g., by flagging atypical energy use). Cell phones may become tools that customers use for managing energy profiles (e.g., push a button to open/close shades).
- **Localized management of the grid with faster data gathering and controls.** There will not be a lot of new functions for bulk transmission, but there will be more variability in loads and generation, which will require more localized management. The ISO/RTO will smooth out this variability for the large-scale grid, but there will be a need for faster data gathering and controls to respond to changes on smaller scales (e.g., the distribution system), especially regarding generation and storage resources. Automated analytics (an exact, real-time model of the system will be needed) and the grid operator will serve as a backstop for larger issues. The grid of the future will require additional infrastructure investment. An increasing number of service options could require additional management.

- **Improved data analytics as an enabling technology.** Enhanced data analytics will make it possible to operate the grid closer to the margin by providing a better understanding of the physical limits of the lines and the overall system in terms of carrying capacity.
- **Ubiquitous appliance-level energy metering.**

Differences for the Operations Centers

Transmission:

- **Enable operation closer to reliability margins.** Utilities have had to depend on models for estimating the grid capacity needed; these models have been overly conservative to ensure operating limits were not exceeded. Increased situational awareness of the conditions on the grid will allow utilities to manage grid capacity with more accuracy. With better metering and data, grid operators will be able to operate the grid closer to reliability margins with existing resources. This will open up value for the last bit of margin.

Distribution:

- **Distribution automation (Conservation Voltage Reduction [CVR], demand response).** Distribution automation will be different and enhanced, and it will save energy and build efficiency into the grid. There will be improved communications between transmission and distribution. Operators will need to understand and be able to see what is happening from one end of the system to the other.

Transmission and Distribution:

- **Increased coordination between transmission and distribution system operators.** Demand response and CVR will require a tighter relationship between transmission and distribution operations centers. Transmission and distribution networks need to improve communications so they will be able to coordinate with each other when events are taking place. Increased granularity will require a way for all of the involved entities to see what is taking place and can allow for better coordination.
- **Communications operations centers need to be tied in to transmission and distribution operations centers.** Increased interaction between the various centers could lead to the blurring of state/federal jurisdictional lines.
- **Need for increased granularity of downstream events and conditions.**

Business Models and Investments

Financial/Business Model Changes:

- **Shift the utility role from commodity provider to provider of customized consumer services (i.e., all-premise management).** Utilities will offer their product differently—they will be a service provider, offering options (e.g., solar, energy efficiency, EVs, security, sharing with neighbor; whatever makes sense to bundle). A modernized grid will enable additional services and products that are not possible today. Utilities should be able to compete openly with other entities that provide services. There is a barrier around the type of products and services that can be offered by different types of entities. This barrier needs to be revisited to determine whether maintaining this protection still makes sense. Utilities will be challenged to provide services to everyone.

- **Broaden mandate from "least cost" to include other metrics such as "best service."** Business models are directly tied to policy. Currently, there is a least-cost and reliability mandate. "Best service" is more value-oriented. Utilities are limited by the least-cost mandate; if they were free to engage in more thought leadership exercises, they could generate more solutions.
- **Utility services may now go behind the meter.** Currently, utilities only provide services upstream of the meter, and regulated utilities have to be preapproved to do anything behind the meter, which keeps them from implementing new ideas. A partnership is needed between utilities and customers for developing behind-the-meter options. To take advantage of apps, electricity providers will have to go behind the meter to provide the necessary service.
- **Enhanced marketing and advertising capabilities.** For most utilities, marketing their products and services will be a new function; they do not currently have consumer-facing marketing capabilities. A culture change may be necessary for utilities—from being commodity providers to being more service-oriented companies. Energy providers will need enhanced marketing to better understand customers, to better advertise and inform customers about their products, and to empower customers to control and manage their energy use. Utilities will probably need to partner with or hire people with these skills.

New Investment/Funding Requirements:

- **Create new rate structures for all grid services (e.g., backup power).** Technology is changing, so the market needs to change. Performance-based rates are an option—with ubiquitous sensing and measuring equipment to help better show energy usage and reduction. Capital and O&M costs associated with grid infrastructure could be recovered via a fee related to the services being provided rather than through the current method of tying recovery to the commodity sale (kilowatt-hours). If consumers want to use their own distributed generation but still connect to the grid as a backup service, they need to pay for the associated cost of this service. To make the infrastructure and maintenance investments required to provide this service, utilities will need a reasonable and established method for recovering the costs associated with providing this backup service. Many utilities do not currently have backup power rates. Rate reform is needed to balance energy usage between low and high usage, similar to cell phone usage rate plans that differ according to users.
- **More transparency and granularity are needed in how costs are calculated and presented to customers.** Currently, there are many hidden and socialized costs. Flat-rate pricing is inefficient and can be considered unfair. Utilities need to be better about allocating costs for recovery (more granular and nonlinear). In addition, utilities need the capability to differentiate costs by type of service, location, and time of day. Customers should be given granular information about costs and pricing. Customers should be informed and understand how various services impact grid operations; for example, the impact of EVs to power parts of a home, or a smart home with automated features that show energy use and how money can be saved/optimized.
- **On-bill financing options for services.** This would allow consumers who want to invest in energy products (e.g., double-pane windows, insulation, solar installation, EV charging) to finance them through the utility, and the utility may or may not provide the product directly.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Keep the regulatory mandate for low-cost, reliable energy, but layer an additional mandate to reward innovation for the benefit of customers.** Low cost and high reliability are important goals, but now is the time to add to those mandates. Regulations are currently conservative and risk-averse, hindering innovation. Regulatory barriers to innovation need to be eliminated. Embracing new technology and applications requires open-mindedness. One participant noted that regulators should remember that the current system works well and is efficient, and that any proposed changes should be evaluated to determine if they will be beneficial. In addition, the regulatory variation between states hinders the scalability of offerings.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Develop a clearinghouse of best practices, data, benchmarks, and case studies on grid investments.** A national resource base or clearinghouse that is easy to navigate for relevant information needs to be established to facilitate learning from others. It would be beneficial for states to determine and share what is and is not working with other states. A collection of case studies could be used to show the benefits of smart grid technology.
- **Educate consumers and policy makers.** Consumers and policy makers need to be educated in order to stay abreast of the rapidly changing landscape. Regulators have a high turnover rate, might not have an energy background, and are very busy. Sometimes they are also inundated with information.
- **Create a more granular understanding of the cost of grid services.** The grid provides a lot of services beyond electricity delivery. The disaggregation of services and their associated costs needs to be done at a more granular level. Having granularity of costs will be important for pricing, cost allocation, cost causation arguments, etc. Cost needs to be understood first. In the future, there could be customized rates for every meter.

Scenario 3. Higher Local Reliability through Multi-Customer Microgrids

Description of the Scenario

This scenario is characterized by:

- Microgrids that are widely deployed to meet a variety of customer needs: increased reliability, greener generation, higher power quality, etc.
- Increased sophistication of these microgrids, with a mature market by 2020.
- Microgrids becoming a dominant force in grid operations in 2030 and beyond.
- Microgrids serving a single customer or multiple customers.
- Microgrids that utilize larger grid infrastructure but are also able to operate independently when necessary.
- A possible disruptive or destabilizing impact of microgrids on the traditional grid (shrinking number of ratepayers to support grid infrastructure, rising costs per ratepayer).

Together, these characteristics suggest a need for:

- Appropriate grid interface standards to allow for optimal operation of the grid, the microgrid(s), and both together.
- Consideration for how these microgrids will impact infrastructure investment for the larger grid.

Path Forward: Articulating the Vision

The following summarizes the Scenario 3 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 3 assumptions. The participants also recognized that there will be a transition period before the end state is reached.

Characteristics of a Microgrid as Noted by Participants

- Will operate in parallel with the grid, not in competition.
- A cluster of energy users with similar needs (resiliency, thermal load, environmental, etc.).
- Considered a grid within a grid.
- Will facilitate more customer-owned generation.
- Energy storage will play a big role in the future of microgrids.

Description of the Group's Future Grid, Based on the Scenario

- **Far more complex load balancing between microgrids and transmission/distribution providers; a marketplace will be required to enable it.**
- **Microgrids likely. Customers could include large customers (e.g., universities, hospitals, apartments, commercial, and industrial) and security-minded customers (e.g., U.S. Department of Defense).** The rationale is that microgrids are cheaper, greener, more reliable, more flexible, and allow local demand to be met with local generation. Customers will not be looking to leave the grid and grid connections will be maintained.

- **Microgrid planning will happen in partnership with the transmission/distribution operators to ensure systems are synchronized.**
- **Redundancy on critical infrastructure (wires will likely still be in place and maintenance will still be required).** The larger grid will provide backup and support to the microgrid.

New Capabilities and Functions

- **Multi-customer and single-customer microgrid operation will be complementary to the grid system. New interconnection technical standards for multi-customer microgrids will be necessary.** Microgrids will complement the grid instead of competing with it, providing services to utilities and vice versa. Aggregating distributed generation into microgrids might offer benefits for managing significant concentrations of distributed generation and customer-owned renewables. Today, many of the customers that have installed microgrids have done so primarily due to their high power-quality requirements. In the future, utilities will be able to call on these microgrids to island on peak demand days or for other operational efficiencies, including reducing the impacts of outages. This will be a win-win when the customer and utility work together.
- **Energy storage manages load variability and renewables intermittency, as well as bolsters microgrid technical/economic feasibility.** Energy storage might be an important microgrid component to help manage the variability of renewable resources, and it could improve the technical and economic feasibility of these systems.

Differences for the Operations Centers

Transmission:

- **Data analytics need to improve.** Data analytics are needed to plan for and manage demand/supply from microgrids. Reliability feedback data does not currently exist, but it will be needed.
- **It is critical to understand—and possibly predict—the limits of utilities' obligation to serve so they are better able to plan for microgrid integration.** If utilities know and understand their obligation to serve in relation to the microgrid, they will be able to plan for it. It is critical to understand in near real time what is happening with the microgrid. From a transmission perspective, understanding the different load characteristics associated with microgrids will be important.

Distribution:

- **Bidirectional real-time pricing (such as what currently exists at the transmission system).** A clearing price will be needed at the distribution level that provides a value, given the current conditions. The clearing price platform will be a critical part of microgrids.
- **Demand data flow will need to be communicated to transmission providers so they can plan for it—especially around peak load time.**
- **A complex coordination problem across potential entities: small customers need to have the ability to coordinate production, protection, and demand.** Distribution operators are used to looking at load flowing in one direction. With microgrids, operators will have different fault characteristics and two-way power flow that must be managed. This raises concerns for utilities regarding protection. The question was raised whether utilities can dictate the level of protection the microgrids would need to provide. Maintaining system balance also becomes more challenging if there is only a small group of customers. Balancing and maintaining grid stability without large base load generation may be difficult.

Business Models and Investments

Financial/Business Model Changes:

- **The utility will embrace two different business models: a deregulated business and a regulated business.** Many utilities think about the difference between regulated and unregulated assets. In the future, this will be a fundamental change for vertically integrated utilities—from a fully regulated mindset to a mix of regulated and deregulated. Many utilities are struggling with this shift. In the long run, the regulated utility will be a smaller part of a much larger corporation. It will still have regulated assets, but it will also have a deregulated side that will be much larger. This is very possible by 2030. Utilities will want customers to view them as value aggregators that can address reliability and asset maintenance. Utilities will be solution providers.
- **Utilities transition to service model (culture shift—design and improve rather than maintain).** Utilities will continue to try to become more involved in providing services to customers, although maybe not directly. Once the market base and customers are defined, utilities can make sure products and services match.
  - End customers will see the utility as a "value aggregator." Utilities will identify customers' energy needs and bring in vendors to meet those needs. Utilities will be the common denominator for communicating with customers where the market is going, helping to identify solutions and bringing in the solution providers.
  - Microgrid operators will view utilities as customers, suppliers, and strategic partners.
  - A key marketing challenge for this model will be whether customers perceive utilities as trusted solution providers (potential other solution entrants).
- **Segment customers to provide premium support and reliability to those who are willing to pay for it.** It will be critical to understand the various needs/wants of customers and to match microgrid solutions to meet those needs/wants. Utilities will need to embrace and know their customers. Often, the customers who leave the grid are the most desirable, have higher expectations, and are willing to pay more for the service provided. One issue that needs to be considered is that as the profitable customers of the utility move off the grid, the less profitable customers are left to support the system—either service goes down or cost goes up. Measures will be needed so that microgrid participants are paying for the utility-provided infrastructure that supports the microgrid; this burden should not be carried by the remaining customers.

New Investment/Funding Requirements:

- **Utilities need to increase data acquisition and eventually build data services.** Data will allow for price transparency and will foster a flexible and free market for microgrid operators to buy and off-load generation. Utilities could use the additional data to connect and understand customer needs.
- **Utilities will need to develop new services and capabilities.** Utilities should be the solution provider for their customers. They will need to engage their customers. From a communications standpoint, utilities will need to be able to measure and validate microgrid performance. Utilities could provide microgrid services. They have the expertise from both insider and outsider perspectives. For example, utilities could offer a suite of microgrids, at different costs, such as a "green microgrid," a "resiliency microgrid," and a "lowest-cost microgrid." There may be areas where utilities want to establish a microgrid for reliability, density, or other reasons. Microgrids could be owned by utilities or customers (with a common goal).

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **It is critical to address the utility's obligation to serve for islanded customers.** There needs to be acknowledgement that microgrid operation is a parallel operation; there is a cost-sharing component for the interaction with the existing grid. The utility's obligation to serve for islanded customers will need to be clearly defined.
- **Allow customer segmentation and a suite of offerings that balance reliability and price.** The suite of offerings for the different wants/needs of customers may involve specific rate schedules, tariffs, and incentives. Energy has a different value at different times to different people. Utilities need to have flexibility to meet the needs of different customer types. The current model does not allow for this.
- **Bidirectional distribution market for electricity—to and from microgrids.** Similar to how a transmission market clears generation at a particular price, electricity should be put back on the distribution market at its value.
- **Policy can unintentionally distort efficient planning.** For example, incentives to build distributed generation that may not match up with production and consumption needs. Tax credits and valuing energy at a nonmarket price can also distort the market. There is a need for a real market-based price for energy at the distribution level. The incentives should not be part of the pricing structure.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Link solutions and market analysis.** Utilities should do a market analysis in order to understand customer segments that could benefit from microgrids. They should also seek to understand market solutions that could launch successfully. Customers all have different needs that will require unique solutions.
- **Coordinate a multi-stakeholder planning and education process.** Industry stakeholders should be brought together in a coordinated planning and education process. Stakeholders should include utilities, grid operators, independent power producers, third parties, consumer advocates, and regulators.
- **Support transparent, bidirectional, real-time, market-based pricing data for distribution.** A distribution market needs to be created to buy and sell electricity between microgrids and transmission providers, along with a fair rate structure to enable it.

Scenario 4: Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Description of the Scenario

This scenario is characterized by:

- Increasingly affordable natural gas; rising use of natural gas.
- Lower costs for wind, solar, and other renewable generation technologies (as a result of incentives and increasing market demand).
- A majority of new generating capacity being supplied by renewables.
- New policies and regulations that are driving up the price of coal, oil, and nuclear.
- New participants in the market; impacts of changing wholesale prices on the profit margins of traditional and renewable power generators.
- New operating characteristics for the generation fleet.
- Possible strain from ramping and cycling.

Together, these characteristics suggest a need for:

- Increased infrastructure to transmit electricity from sites where it is produced to where it is used.
- Increased flexibility of the power system to manage the variability and uncertainty of generation from intermittent renewables.
- Strategies for addressing increasing penetration of non-dispatchable resources; curtailment.
- New alternatives to traditional planning processes to avoid overbuilding some asset capacity and underbuilding others.

Path Forward: Articulating the Vision

The following summarizes the Scenario 4 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 4 assumptions. The participants also recognized that there will be a transition period before the end state is reached.

Description of the Group's Future Grid, Based on the Scenario

- **Improved monitoring, analytics, and responsiveness.** There is going to be a lot of information—energy providers will need to have an improved capacity to gather and process it. Gathering and processing the information will be complex because there will be more resources that are more intermittent. The system will need to be nimble, flexible, responsive, and more data-driven, and it will require additional analytics and control. Communications will be very important for the grid of the future.
- **Complex control of variable power sources, loads, and storage.** Balancing the increased variable sources and loads will be more difficult. The current model involves centralized generation. With more localized generation, energy providers will need to gather and consolidate all of the information to understand and process it.
- **Increasingly diverse.** The diversity of energy sources will continue, and perhaps increase; some utilities will continue with business as usual, and some will adapt to the changing technology.

The grid will continue to evolve. If bringing in storage is cost beneficial, then utilities will need to figure out how to make it work in the system.

New Capabilities and Functions

- **Increased customer choice and control.** Services need to be differentiated. Consumers want more control. People need to have choices and control over those choices. Some customers will want more reliability, and some will want "greener" electricity. Residential and industrial customers may want different levels of reliability.
- **More accurate weather forecasting (wind, cloud cover).** Solar and wind power are highly dependent on weather. More accurate forecasting will be important for addressing variability and allowing the necessary adjustments to be made to the system. There will be a need for more accurate micro-weather forecasting.
- **Decentralized, automated operations.** There will be a shift from a centralized model to a more local model, with more decentralized decision making. Operations will be more automated.

Differences for the Operations Centers

Transmission and Distribution:

- **More coordination between operating centers.** There will be transactions going from distribution to transmission, so the operating centers will need to be more tightly knit. There will be greater cooperation on interfaces and operating centers, both horizontally and vertically. Transmission operators will need more visibility into the distribution grid, which will bring transmission and distribution operations closer together.
- **Advanced analytics and visualization of near-real-time data.** This will require greater automation and oversight. Better tools will be needed to analyze the huge amounts of data.
- **New operator skill sets.** The changing operational structure will require a new set of skills for grid operators. Grid operators will need to be open minded to the changes taking place.

Business Models and Investments

Financial/Business Model Changes:

- **Disaggregation of costs.** The cost of energy needs to be broken out to show the actual cost of each component so that consumers can understand what they are paying for and the services they are receiving.
- **Customers bear the costs that they cause.** Capital investments were made to build the grid infrastructure. Customers who have their own generation but want to connect to the grid for reliability or other reasons must contribute to the overall infrastructure they are using and from which they are benefiting. It would be easy if utilities had zero capital investment and everyone was responsible for the cost of the system they create, and if utilities were free to participate in any business.
- **Cost recovery of sunk costs.** Utilities fear not being able to recover the costs of their investments as people decide to self-generate but still use the grid. This relates to the concept of customers paying for what they use. The industry needs a specific working group to allow utilities and other stakeholders to discuss how to recover sunk costs with the changing environment.

New Investment/Funding Requirements:

- **New funding mechanisms for public good.** Sometimes new transmission lines will be needed to support public policy—"for the public good"—and should not be totally funded by the "ratepayers" in the state where the line is being built. For example, the transmission system that is part of a bigger purpose—such as national security or encouraging renewables—might need funding from a broader group. Right now, only grid customers in the service territory of that line pay for that infrastructure.
- **Equitable funding of public goods programs.**

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Rate reform must start now.** Rate structures need to be reformed, and a method of paying for existing infrastructure needs to be developed. The disaggregation of costs needs to start now; industry should not wait until there are problems, and the issue cannot wait until 2030. Customers should be educated about the true costs and allowed to pay for what they need; it should be a fair competition. Right now the system has a cost component that is socialized, regardless of use, but customers may only want to pay for services they are using.
- **A long-term outlook for policy is needed.** There needs to be a roadmap that provides checkpoints that help ensure that progress is moving along the right path. Policy makers should be educated about the benefits of the current system and cautioned to bring about change thoughtfully rather than based on uninformed speculation.
- **Account for people who cannot transition to new technologies.** A substantial number of customers will be unable to participate in microgrid or solar efforts (including people who live in apartment buildings, not just people who cannot afford these efforts). Grid policy needs to account for both those who can and cannot participate.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Build a comprehensive coalition of stakeholders to drive regulatory reforms.** A conversation is needed among stakeholders. The more people talk about this, the better people will understand the issues. This coalition should include utilities and intervenors.
- **Develop markets for selling and buying services.** Once it is determined what services will be included in electricity service, these services can be broken out and marketed. Everyone should be allowed to participate in the market. These markets must facilitate the buying and selling of not only watts but also other ancillary services such as reactive power.
- **Educate the regulatory community and consumers.** Educating customers and policy makers about how electricity works, what the costs are, and the complexities and simplicities of electricity will be critical. Customers should be educated in *their* language, not in technical language. There are a broad variety of customers who have a different understanding of the electricity industry.

Conclusion and Next Steps

The Southeast Region workshop provided an interactive forum for participants to identify a vision of the future grid based on their given scenario from a Southeast Region perspective. Stakeholders participated in productive discussions, and the output from this workshop represents an excellent step in gathering viewpoints from stakeholders nationwide. Participants praised the usefulness of the small group discussions that allowed for frank conversations and provided a forum to hear various stakeholder perspectives in an open, constructive format.

Output from this workshop, as well as from the previous and subsequent regional workshops and the National Summit in Washington, DC, will feed into a final report, which will be published after the National Summit.

Appendix A. Setting the Stage: Factors to Consider

In order to frame the workshop discussions, participants received pre-read materials describing the scenarios and highlighting a number of key factors to consider that are shaping the electrical grid today and will likely emerge as dominant forces by 2030:

The shift to renewable generation. Rapid growth in wind capacity will continue, boosted by lower-cost, larger-sized turbines; larger production volumes; tax credits; consumer interest; and improved capacity factors. Solar photovoltaics (PVs) will also grow rapidly, driven by higher demand, consumer interest, lower PV module costs, and support from tax credits and other incentives. Although both wind and solar represent a small portion of the total electricity market, in regions where these resources are abundant, they can be disruptive and pose challenges to the grid. Biopower, geothermal, and hydropower will also grow rapidly. Some coal-fired plants may be retired.

The rise of cheap natural gas. Low natural gas prices and tightened emissions requirements will create more demand for natural gas from the power sector. Natural gas generation will grow through 2050, as low costs make existing natural gas plants more competitive with coal, and lower capital costs make natural-gas-fired plants a viable choice for new generation capacity.

Growing building energy efficiency. Growing federal adoption of Leadership in Energy & Environmental Design (LEED) standards for new building construction and state programs such as California's Zero Net Energy Building initiative will drive a broader growth of high-efficiency residential, commercial, and industrial building efforts that also feature on-site renewable energy generation or the purchase of renewable energy from utilities. The renewable requirements and possibility of on-site generation will greatly affect the performance of the grid, both locally and holistically, with implications for grid operation and stability.

The maturing of demand response. There will be increased availability of demand-side management to reduce peak demands, which in turn may help defer new generating capacity or improve operator flexibility in day-ahead or real-time operations. Dynamic pricing, time-of-use pricing, incentive payments, and other strategies will encourage users to change their energy consumption patterns. State policies and federal technical assistance, research, and development will help drive adoption of demand response.

The smart grid. In response to aging infrastructure and a desire to increase electricity transmission and distribution efficiency, there will be an increased push for technology that utilizes remote controls and automation to better monitor and operate the grid. Increasingly over the past decade, Congress has taken a serious interest in electrical grid issues by passing various laws to address them. Title XIII of the 2007 Energy Independence and Security Act includes language specific to the smart grid. Congress continues to consider new legislation to address cybersecurity concerns, privacy and data access for consumers, and other policies to accelerate investments in the future grid.

Growth in energy storage. Maturing energy storage technologies will provide flexible solutions throughout the electricity value chain, helping grid operators address energy management, the intermittency of renewable power sources, and power quality issues.

Increase in microgrids. North America was the leading microgrid market in 2013, and it will remain so in the future, with major growth expected in the United States and worldwide. With the U.S. Department of Defense as an early adopter, and public investment in microgrids from a variety of other state, federal, and university entities, microgrid integration will be a crucial element in addressing grid reliability and resilience issues associated with energy generation from distributed renewables, power outages from natural disasters, and the increasing impacts to national security.

Smart cities and smart appliances. The amount of data being created and collected by municipalities and utilities is growing rapidly; by some estimates, it is expected to double every two years until 2020. Understanding and leveraging this data will be critical for municipalities. To maximize participation in smart cities, stakeholders will need to plan grid development in conjunction with planning authorities. Residential "smart appliances" are expected to become increasingly mainstream in 2015 and could reach up to $35 billion in sales by 2020.

The rise of electric vehicles (EVs). EV sales account for less than 1% of total new light-duty vehicle sales, but federal support, state support, purchasing incentives, and fueling costs are aimed at boosting their adoption. The ways in which charging will impact the grid remain to be seen. The U.S. Department of Energy is encouraging more workplace charging. Technology advances could make quick chargers, wireless charging, or other methods more common at home. Utilities will need to evaluate their distribution system against these possible demand scenarios.

Overall growth in energy demand, with higher industrial demand and lower residential demand. Overall energy use is expected to increase by 2040. The U.S. Energy Information Administration (EIA) projects industrial-sector energy use to grow by 5.1 quadrillion British thermal units by 2040, primarily due to the increased use of low-priced natural gas and an increase in industrial shipments. However, EIA projects average electricity demand per household to decline by 6% by 2040.

A rising frequency of extreme weather events. Weather-related issues are the cause of nearly half of U.S. outages and are on the rise, meaning that grid resiliency will need to be addressed. In light of Superstorm Sandy, local leaders are considering options for local generation to address the most critical loads. Investments are being made in distributed power systems.

Policy and regulation. The grid will need to accommodate, forecast, and communicate with renewable generation resources spurred by renewable portfolio standards. The continuation of existing demand response policies would lead to a 4% reduction in U.S. peak demand by 2019. Renewable requirements for buildings and the possibility of on-site generation greatly affect the performance characteristics of the grid. Some states have launched emissions goals and cap-and-trade programs that may affect electric power producers and industry and shift production toward renewables.

Aging infrastructure and limited addition of new transmission capacity. Much of the U.S. power infrastructure is outdated and needs to be refurbished, replaced, or upgraded. Updating the existing infrastructure will present many challenges. These updates will become more and more necessary as the age of the infrastructure begins to show. Utilizing smart grid technology will increase grid resilience, efficiency, and reliability. The federal government has allocated billions of dollars to replace, expand, and refine grid infrastructure.

Appendix B. Workshop Agenda

The Future of the Grid: *Evolving to Meet America's Needs*

Tuesday, April 8, 2014 • 7:30 am – 4:00 pm

Duke University • R. David Thomas Executive Center • One Science Drive • Durham, NC 27708

7:30 am **Registration and Continental Breakfast**

8:00 am **Welcome**

Becky Harrison, CEO, GridWise Alliance

Eric Lightner, Director, Federal Smart Grid Task Force, US Department of Energy Office of Electricity Delivery and Energy Reliability

8:10 am **Opening Remarks**

Dr. Daniel Vermeer, Executive Director, Energy, Development and the Global Environment (EDGE)

8:25 am **Stage Setting: External Factors and Variables Impacting Future Electricity Delivery**

Mark Wimberly, General Manager, Program Management Office, Grid Modernization, Duke Energy

8:50 am **Visioning Exercise: A Future Grid – Capabilities and Functions**

Facilitated discussion with the entire group

If you were starting with a "blank sheet of paper" and did not have any constraints that are imposed by the legacy infrastructure and business models:

- How would you define the future role of the grid?
- What would the future grid look like?
- What capabilities and functions would be necessary to meet society's needs?
- What do grid operations look like?

9:25 am **Break**

9:35 am **Breakout Sessions**

Participants will be assigned to one of the following breakout sessions. A description of the scenarios will be provided in the pre-read materials. Breakout group assignments will be given to participants during registration.

Scenarios

- The Challenge of Balancing Supply and Demand as Grid Complexity Grows (Orange)
- The Challenge of Involving Customer and Their Electrical Loads in Grid Operations (Yellow)
- The Challenge of Higher Local Reliability Through Multi-Customer Microgrids (Red)
- The Challenge of Transitioning Central Generation to Clean Energy Sources – Big Wind, Big Solar and Big Gas (Green)
- The Challenge of Planning for Empowered Customers (Blue)

Scope and Task

In the afternoon session, each breakout groups will be reporting out on their Grid of the Future, which is based on their scenario, and will provide answers to the following questions:

- What capabilities or functionality will the grid need to have?
- How will the operations center function?

Scope and Task Continued

- What is the one technical limitation or operational constraint that a policy maker would

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need to know when developing future policies so as not to adversely impact electricity delivery?
- What three actions must be undertaken in order to evolve to your cost effective, reliable, and resilient grid of the future?

9:35 am **Breakout Group Discussion: *Defining Grid Operations***

For both the transmission and distribution systems:

- How does the grid have to evolve to get from where we are today to the future vision?
- What capabilities and functions will it need to have?
- How will the operations centers function?
- How will the interaction between transmission and distribution change?
- What are the technical capabilities that will be needed that don't exist today?

11:05 am **Breakout Group Discussion: Business Models and Investments**

- What market structure changes, if any, will be necessary to ensure the future viability of utilities and to move from a commodity to services model?
- How will grid owners/operators make money (rate based versus performance based)?
- What will be the new investment and funding requirements?
- How will both capital and O&M costs be covered?

12:00 pm **Lunch**

12:45 pm **Breakout Group Discussion: Regulatory and Policy Barriers and Opportunities**

- What are the policy and regulatory barriers at the state and federal levels?
- Do regulatory bodies have the authority they need to make the necessary business model changes?
- Are there opportunities that must be embraced now?

1:40 pm **The Path Forward: Articulating Your Vision for Report Out**

- Provide answers to the questions posed in the Scope and Task section above.
- Select a spokesperson to present the group's vision
- Select 4 "panelists" who represent different stakeholder groups to participate with the spokesperson for the Q&A session

2:10 pm **Break**

2:20 pm **Report Outs**

Breakout groups will report the results of their discussions back to the larger group. Breakout groups will have 5-7 minutes to present their vision followed by a 10 minute Q&A session.

3:45 pm **Summary and Final Thoughts**

4:00 pm **Adjourn**

Appendix C. Attendees

Greg Andeck
Environmental Defense Fund

Howard Andres
Energetics Incorporated

Charles Bayless
North Carolina Electric Membership Corporation

Ron Belvin
Duke Energy

Elizabeth Bennett
Duke Energy

Ronak Bhatt
University of North Carolina at Charlotte

Blakely Blackford
Duke University

Jamie Bond
Duke Energy

Tanya Burns
Energetics Incorporated

Ward Camp
Landis+Gyr

Lee Coogan
GridWise Alliance

Cyrus Dastur
Advanced Energy

Don Denton
Consultant

Patty Durand
Smart Grid Consumer Collaborative

Luis Fondacci
North Carolina Electric Membership Corporation

Ladeene Freimuth
GridWise Alliance

Kim Getgen
Tollgrade Communications

Mark Gray
Civergy, Inc.

Leonard Green
North Carolina Utilities Commission

Becky Harrison
GridWise Alliance

Steven Hauser
New West Technologies, LLC

Dave Herlong
FP&L

Ray Hohenstein
Duke University

Doug Houseman
EnerNex

Brian Hughes
Duke Energy

Avnaesh Jayantilal
Alstom Grid

Jesse Johnson
Duke University

Kerrick Johnson
VELCO

Mark Johnson
Energy Central

Stephen Kalland
North Carolina Solar Center

Cindy Keene
Duke Energy

Caroline Kramer
Energetics Incorporated

Lee Krevat
San Diego Gas & Electric

David Lawrence
Duke Energy

Fred Leffler
Duke University

Ward Lenz
Advanced Energy

Eric Lightner
U.S. Department of Energy

David Lubkeman
North Carolina State University

Paul McCurley
NRECA

Joel McManus
Lockheed Martin

Melanie Miller
Duke Energy

Jonas Monast
Duke University, Nicholas Institute

James Musilek
NCEMC

Greg Nulty
Tollgrade Communications

Ron Pate
Elster

Julie Perez
New West Technologies, LLC

Tim Profeta
Duke University, Nicholas Institute

Douglas Proudfoot
Quanta Technology

Gary Rackliffe
ABB

David Schleicher
EnergyUnited EMC

Russell Schussler
Georgia Transmission Corporation

Barbara Servatius
Nexans

Evan Shearer
Duke Energy – Grid Mod.

Larry Shirley
Duke University, Nicholas Institute

Mark Smith
Tennessee Valley Authority

Aaron Snyder
EnerNex, LLC

Stephen Spivey
Santee Cooper

Kenneth Van Meter
Intelligent Energy Solutions, LLC

Tatjana Vujic
Duke University

Christa Wagner Vinson
Research Triangle Cleantech Cluster

Dylan Waugh
Energetics Incorporated

Jennifer Williams
Duke University

Mark Wimberly
Duke Energy